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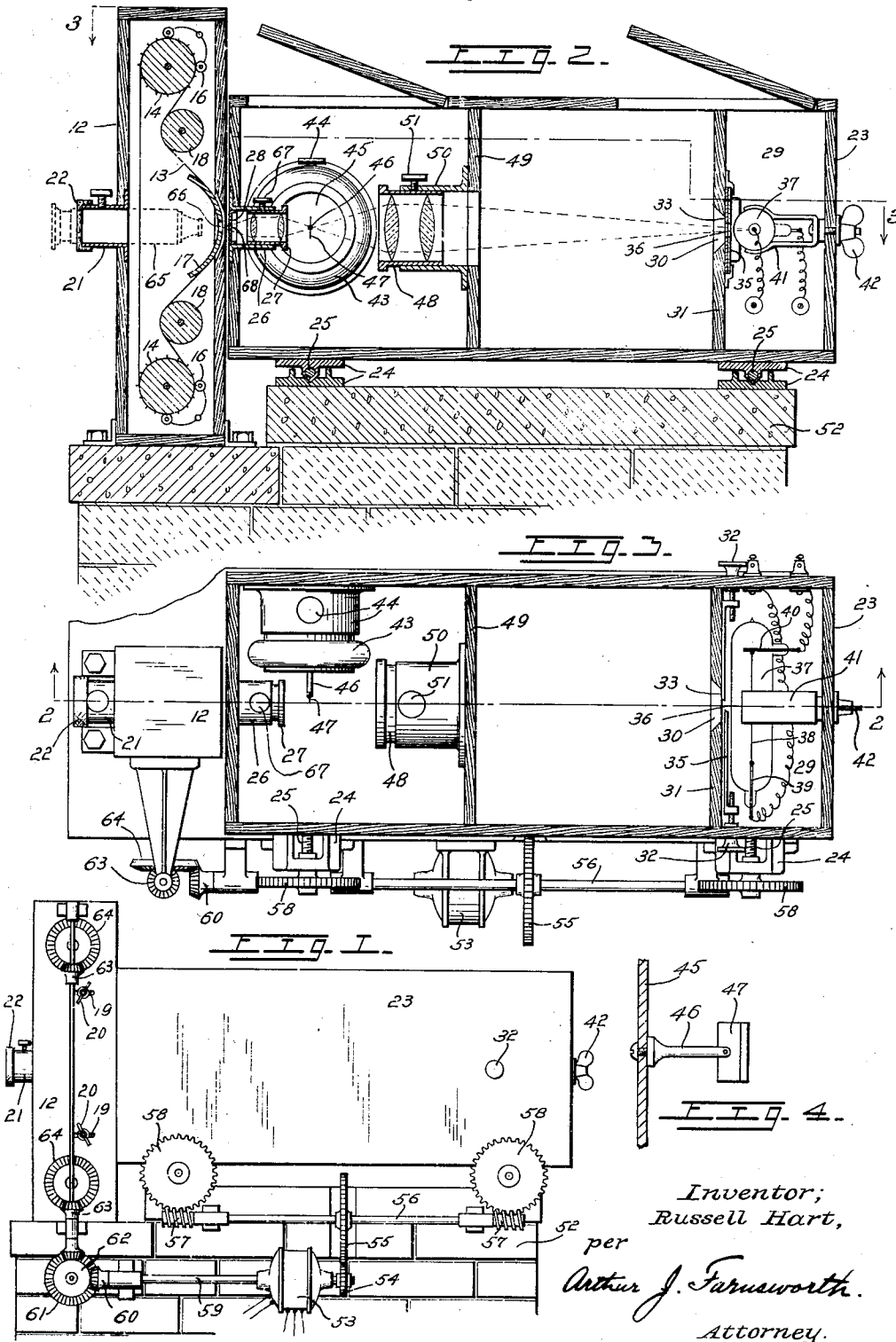
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TELEPHOTOGRAPHIC RECORDING APPARATUS

Filed July 2, 1923

2 Sheets-Sheet 1



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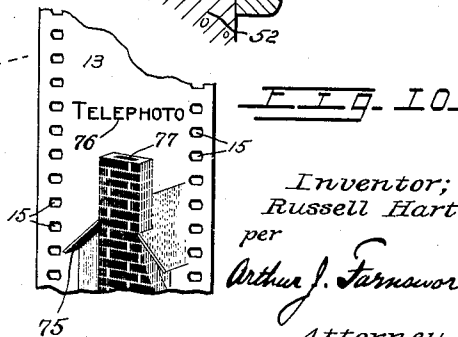
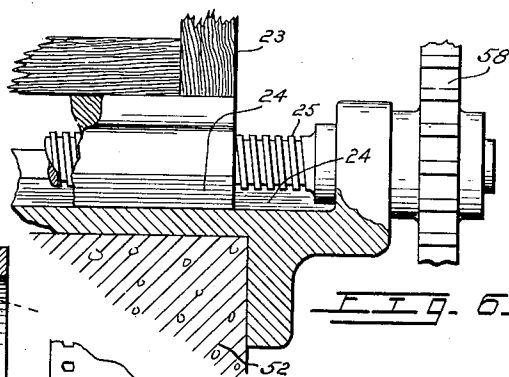
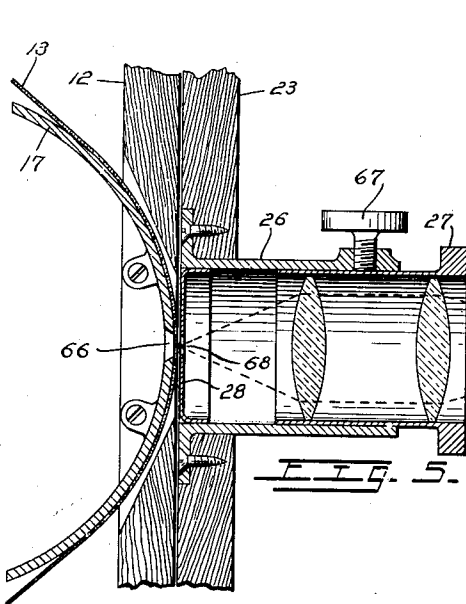
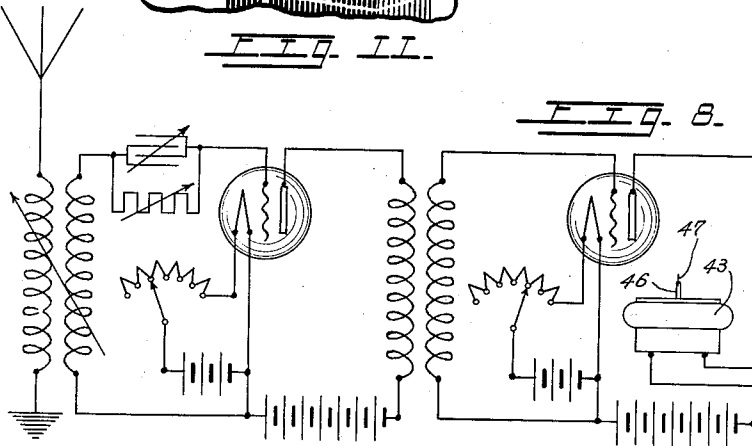
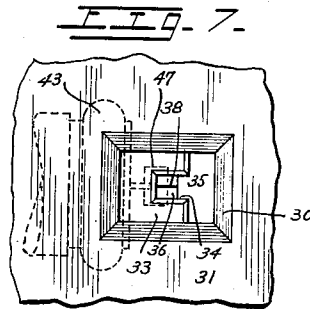
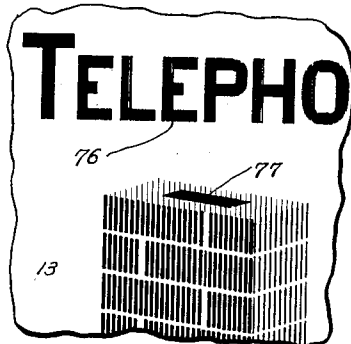
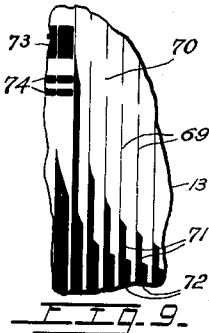
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TELEPHOTOGRAPHIC RECORDING APPARATUS

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE.

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TELEPHOTOGRAPHIC RECORDING APPARATUS.

Application filed July 2, 1923. Serial No. 649,085.

My invention relates to telephotography, and its objects are; first to provide means for receiving photo-modulated energy transmitted from a remote point, either by radio, wired radio, or. wired systems; second to afford facilities for the utilization of this energy for the reproduction of drawings, photographs, printed matter, and the like; and, third, to accomplish the above results by means of relatively simple and thoroughly dependable apparatus. Other objects and advantages of the invention will appear hereinafter.

It is to be understood that, while I illustrate and describe herewith a preferred means for accomplishing my objects, I do not limit myself to the specific forms and arrangements disclosed. Various changes and adaptations may be made therein without departing from the spirit of my invention as hereinafter claimed.

My objects are attained by means of the apparatus illustrated in the accompanying drawings, which are to be considered as diagrammatic throughout, rather than strictly pictorial. In these drawings—

Figure 1 is a side elevational view of the photographing portion of my apparatus;

Figure 2 is a central longitudinal section of the same in elevation, and on a somewhat larger scale, the section being taken on the line 2—2 of Fig. 3.

Figure 3 is a plan view shown partly in section on the line 3—3 of Fig. 2 and on the same scale as the latter.

Figure 4 is a greatly enlarged fragmentary view of the light modulating target which, in the present illustrations, is shown mounted upon the diaphragm of an ordinary telephone receiver but may be attached to any vibratile electro-operated device that is responsive to minute variations of current;

Figure 5 is a much enlarged longitudinal section of the exposure portion of the apparatus in elevation;

Figure 6 is an enlarged cross section of a portion of the traversing mechanism;

Figure 7 is an enlarged elevation showing details of the adjustable shutter used for varying the visible length of the incandescent filament used as a light source;

Figure 8 is a wiring diagram illustrating one way in which the various electrical de-

vices which are employed in connection with my invention may be connected up;

Figure 9 is a greatly magnified diagrammatic view of a small fragment of a telephotographic film made by my device, illustrating the character of the record and how the effects of light and shade are secured;

Figure 10 is a view of a short strip of the recorded film as thus produced; and

Figure 11 is a greatly enlarged view of a portion of the film illustrated in Fig. 10.

Similar reference numerals refer to similar parts throughout the several views.

Before passing to a detailed description of the construction and operation of my invention it should be understood that its purpose is to photographically reproduce, as exactly as possible, an optical film used for transmitting purposes at a remote point. The recording film used in the present invention is necessarily of the same length and width as the transmitting film, and each of these is made in the form of an endless belt embodying positive driving means in its construction. These two films are run simultaneously, and in perfect synchronism, at separated points.

The synchronizing of the films may be conveniently accomplished by the use of synchronous motors connected into the same power distribution system when this is feasible. Where the distance, or the conditions are such that it is not possible to connect both motors into the same power distribution network, the synchronizing may be effected in various ways known to those familiar with these arts. For example an alternating current wave, originated by the power system that operates the transmitting motor and synchronous therewith, may be sent out by radio or wire line to the receiving station, and there amplified by thermionic devices to a strength sufficient to run the receiving motor.

In a companion application, filed coincidentally with this, I have disclosed means for photo-modulating electric energy waves by the use of an endless optical film having graphs thereon. The modulation is therein accomplished by causing a photo-sensitive modulating device to continuously traverse an image of the transmission film in successive closely spaced parallel lines which may

be considered as constituting a continuous helical path of very small pitch around the endless film. The whole of the film surface is ultimately covered in this manner and the graphs thereon may be considered as being divided into very narrow and closely spaced strips which are run past the modulating device in proper sequence for the purpose of modulating the outgoing energy wave in accordance with their instantaneous optical characteristics. The outgoing energy waves may be transmitted either as radio, wired radio, or wired energy by methods explained in the application referred to.

The present invention comprises a substantial reversal of the above process. The incoming photo-modulated energy waves are received by suitable devices and amplified when necessary. This modulated energy is then caused to proportionally vary the visible length of a tenuous light source whose image is focused upon a photo-sensitized film which is continuously moving in synchronism with the film being used for transmitting. The image of the light source is continuously advanced transversely to the moving film so that the exposure when completed constitutes a narrow helical band, of small pitch, around the recording film.

The simultaneous co-operating processes of the sending and receiving apparatus allow of securing either a positive or negative record at the receiving end, depending upon the arrangement and characteristics of the photo-modulating devices used. Ordinarily a negative film will be used for transmitting, and a series connected selenium cell, or its equivalent, will be employed for modulating the transmitted energy. In this case the high lights of the original graph will correspond to opaque areas on the transmitting negative film. These areas will allow very little light to fall upon the modulating device and the instantaneous value of the transmitted energy will be low. This small energy will have a proportionally small effect upon the modulator at the receiving end, and result in a correspondingly slight exposure of the receiving film at that point. As a consequence the development of this film will produce a transparent area of high light, corresponding to the high light on the original graph. A positive transmitting film may be used for producing a positive recording film if either of the two modulating devices has its photo-characteristics reversed as by mechanical or electrical arrangement.

The telephotographic receiving apparatus constituting the present invention, as herein illustrated, comprises a fixed upright exposure camera 12 wherein the recording film belt 13 is mounted upon driving sprockets 14. The film itself is provided with sprocket perforations 15 at each edge. The spacing of these perforations is uniform and their

number is the same as that of the transmitting film. Spring constrained rollers 16 prevent the film belt from becoming disengaged from the sprockets in operation.

The film belt is mounted with its photo-sensitized surface outward, and is caused to pass over the convex exposure plate 17 which is let into the side of the exposure camera box in such a manner that its apex is substantially flush with the outer surface of the box. This construction is shown most clearly in Fig. 5.

Idler drums 18, having axes transversely adjustable in slots 19, as by the wing nuts 20, are provided for regulating the tension on the film belt.

At the rear of the exposure camera, in line with its transverse axis, is a focusing tube 21 which ordinarily is closed by a cap 22. The purpose and use of this will be explained later.

The light modulating camera comprises a horizontal box structure 23 mounted upon a pair of V guides 24 in such a manner that it may be given a slow uniform motion transverse to its axis, by means of the feed screws 25. The mounting is such that one end of this camera may be moved transversely in very close proximity to the face of the exposure camera, but not in actual contact therewith, since friction and vibration are necessarily to be avoided. The modulating camera has a fixed end tube 26, opposite the exposure plate in the exposure camera. This tube is used for focusing, in a manner to be explained later on, and also as a housing for the objective lens group 27 and diaphragm 28.

At the opposite end of the modulating camera is a chamber 29, containing the light source and having an axial opening 30 in the dividing partition 31. This opening may be variably closed by a pair of overlapping slides controlled by thumb screws 32 on the outside of the camera. One of these slides, 33, is deeply indented as at 34, and in co-operation with the other slide 35 provides a rectangular opening 36 of constant width and variable length. The edges of the slides constituting this opening are preferably beveled to a sharp edge, as indicated most plainly in Fig. 7.

For the source of light I prefer to employ a special form of incandescent electric lamp shown at 37. This contains a thin linear filament 38 of tungsten, stretched between an axial terminal 39 and a transverse resilient terminal 40 adapted to maintain the filament in tension at all temperatures, and therefore rectilinear. This lamp is mounted in a clamp 41 with its filament intersecting the axis of the camera at right angles. Means for adjusting the angular position of the filament in its vertical plane are provided by the wing nut 42.

The modulating device comprises a telephone receiver 43, or its equivalent. This is adjustably mounted upon one of the interior side walls of the modulating camera as by the cup and set screw 44. The diaphragm 45 of this receiver carries at its center a post 46, at the outer end of which is affixed a sharp edged transverse target 47.

Between the modulating device and the light source there is a lens group 48, coaxial with the camera and mounted in such a manner that it may be focused. A convenient means of mounting comprises the partition 49 and fixed tube 50, into which the lens housing may be slid and positioned by the set screw 51.

As indicated above, the exposure camera 12 is fixedly mounted, while the modulating camera is mounted on V guides so that it may be slid transversely to its axis. In order to maintain proper positioning of the cameras it is desirable to install them upon a substantial pedestal 52, of masonry, and in a location as free as possible from vibration. A synchronous motor 53 is attached to this pedestal and serves to drive all of the operating mechanism simultaneously and at proper relative and absolute speeds. Thus the traversing of modulating camera 23 is accomplished through the medium of pinion 54, spur gear 55, shaft 56, worms 57 and worm wheels 58, which are fixed upon feed screws 25. The film is rotated by means of shaft 59, bevel pinion 60, bevel gear 61, bevel pinion 62 and the two bevel pinions 63 driving the bevel gears 64. The latter are affixed to the shafts of sprockets 14. The ratios of the several gear trains is so chosen that feed screws 25 make one complete turn coincidently with one complete revolution of the film belt. The motor, as previously explained, is synchronized with the motor of the remote transmitting device and its speed is so chosen that the transmitting and recording films have the same period of revolution.

The various electrical devices used with my present invention, aside from the motor and light source, are diagrammatically indicated in Fig. 8. This figure shows a typical arrangement of circuits for receiving modulated radio energy from a telephotographic sending station, and utilizing it for the modulation of light for recording purposes by the apparatus herein described. Conventional symbols are employed in this figure and it will be readily understood by those familiar with the radio art. Obviously other circuit arrangements might be employed for receiving radio energy, and changes in the arrangement and use of standard apparatus will be required for the reception of the modulated energy by wired radio, or wired systems. The conditions will

plainly indicate what these changes should be, and it is not necessary to describe them herein.

Passing now to the method of operating this invention, the first step is to focus a very sharp image of luminous filament 38 in the plane of target 47. For this purpose lens group 27 is removed from its tube and a suitable tubular microscope is inserted in its place. Such a microscope is indicated in dotted lines at 65 in Fig. 2, inserted in tube 21, where it is subsequently used for focusing a sharp secondary image of the filament upon the sensitized surface of film 13.

In order to accomplish the first step of the focusing the modulating camera has to be moved a sufficient distance past camera 12 to allow the microscope to be inserted in the tube 26. By the aid of the microscope the razor edge of target 47 is then brought up to the optical axis of the camera and adjusted perpendicularly thereto. This is done by moving the modulating telephone 43 in or out of tube 44 and tightening the set screw when the target is correctly positioned. The microscope is next carefully focused upon the razor edge and then, without disturbing its adjustment, lens group 48 is moved in or out of its tube until an image of filament 38 appears perfectly sharp in the microscope. Set screw 51 is then tightened, the microscope is removed from tube 26, and lens group 27 is replaced in that tube.

The second step of the focusing consists in placing the microscope in tube 21 and inserting a piece of exposed developed film in camera 12, over the exposure plate, with its exposed surface outward and in the position the recording film is to occupy. The microscope is then accurately focused, through aperture 66 and the transparent material of the film, upon the crystals in the exposed surface of the film. Next, the exposed film is removed and, without disturbing the adjustment of the microscope, lens group 27 is moved in or out of its tube until a secondary image of the filament appears perfectly sharp in the microscope. Set screw 67 is then tightened and the focusing of the device is complete.

The next step in the operation is to adjust orifice plates 33 and 35 so that the target just eclipses the secondary image of the filament when diaphragm 45 is in its normal position with no current flowing in the modulating device; and so as to shut off as much as possible of the visible length of the filament without eclipsing the primary image above the razor edge when the latter is in its retracted position with maximum current flowing in the modulating device. The object in this is to allow a sufficient visible length of filament to permit the target to perform its eclipsing function throughout

the whole range of its vibrations; but at the same time it is desirable to cut off all stray light rays so far as this is possible.

The purpose of the small orifice 68 in diaphragm 28 is to further assist in blocking off stray light. In practice it is frequently desirable to use a narrow slit at this point instead of the circular orifice depicted, and in either case it must be carefully positioned so as not to shut off any portion of the secondary image falling upon the recording film.

After completing the above steps the microscope is removed from tube 21, cap 22 is replaced, and an unexposed film belt 13 is placed in its proper position in exposure camera 12. Thereafter, assuming that the electrical detecting and amplifying devices indicated in Fig. 8 are properly set up and adjusted, the apparatus is ready to be started upon signal from the transmitting station.

The character of the record produced by my apparatus can best be described by first referring to Fig. 9. This is a very greatly magnified view of a small fragment of a record film after development.

As previously indicated the recording operation consists in exposing a continuously moving photo-sensitized film belt to the action of a very small image of a very thin luminous filament; the image being transverse to the direction of motion of the film, and varying in length in consonance with the photo-modulated energy sent out by the transmitting station. The image is continuously moved in a direction transverse to the motion of the film so that the latter is ultimately exposed in a helical band of varying width but uniform pitch. The successive bands do not overlap, but vary in width from nothing to very nearly the pitch of the helix, so that at times the exposed surfaces are only separated by a minute space. The pitch of the helix is also very small, being ordinarily from 1 to 2 one hundredths of an inch. This pitch corresponds to the distance between the parallel lines 69 in the magnified view of Fig. 9.

When the target 47 completely eclipses the image of the filament there is no exposure of the film and, after development, the latter presents a transparent surface as at 70. When only a minute portion of the light from the filament is allowed to fall as an image upon the film, the latter is exposed in thin lines as at 69. As the photo-modulated energy from the transmitting station increases, the target 47 is drawn further away from the optical axis of the camera, and a longer image of the filament is thrown upon the film. This results in broader exposed lines, as at 71. At the instant of peak transmitted energy, the exposed bands become relatively very wide

as at 72, 73 and 74. When side by side, as at 73 in Fig. 9, these relatively wide bands, although in fact they are slightly spaced, give the film the appearance of having a solidly exposed area when viewed from a small distance.

Surface shading of the record is accomplished by varying the width of the bands in the manner just described, from nothing to a width approximating the pitch. Horizontal lines, transverse to the record, are produced by short lengths of wide bands side by side as at 73 and 74.

The pictorial effect that may be attained by this method of shading is illustrated in Fig. 10. Here the picture of the house is produced by uniformly spaced parallel lines of different widths. The end of the house is represented by fine lines and appears as a light grey. The face of the chimney is made up of heavier lines of the same spacing and appears much darker. The shadow under the eaves at 75 appears still darker, as the component lines are still wider. The joints between the stones of the chimney appear white, since there are no exposure lines at all at those points. The letters at 76 appear to be solid black since the spacing between the lines is invisible at a short distance. This is also true of the chimney flue at 77.

If we were to magnify the upper portion of the film shown in Fig. 10 we would get the effect shown in Fig. 11. Here again, when viewed at a slight distance, the lettering and the chimney flue appear to be solid black, but a closer inspection shows that all the lines are, in fact, spaced.

The construction and operation of my invention will doubtless be clear from the foregoing description and need not be further elaborated. It will be seen that it is applicable to the transmission of all graphical material including drawings, photographs, printed matter and the like.

I claim:

1. Tele-photographic recording apparatus comprising; an endless photo-sensitized recording film; means for imparting a uniform helical motion to the film; a linear light source; means for projecting an image of said source transversely upon said film; and means for continuously varying the length of said image proportionately to transmitted photo-modulated energy.

2. Tele-photographic recording apparatus comprising; an endless photo-sensitized recording film; means for imparting a uniform helical motion to the film; a rectilinear light source of relatively great tenuity; means for projecting an image of said source transversely upon said film; and an opaque target responsive to photo-modulated energy, whereby the rays from said source may be variably eclipsed to alter the

length of said image proportionately to coincident changes in said energy.

3. Tele-photographic recording apparatus comprising; an endless photo-sensitized recording film; means for imparting a uniform helical motion to the film; a rectilinear light source; means for projecting an image of said source transversely upon a plane; an opaque target vibratile to photo-modu-

lated energy in said plane having an edge transversely intersecting said image for modifying its visible length beyond the plane proportionately to coincident changes in said energy; and a lens intermediate the target and the film adapted to focus a secondary image of the first said image upon said film. 10 15

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